# A Green Criminological Framework for PM2.5 Pollution Prevention in the Bangkok Metropolitan Region

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## Abstract

Since PM2.5 pollution is often considered an environmental crime, this study proposes a green criminological framework for PM2.5 pollution prevention in the Bangkok Metropolitan Region based on the problem-solving approach for crime prevention. Three data collection methods were applied in this study: documentary research, in-depth interviews, and focus groups. There were 26 participants in total. Qualitative content analysis was employed to identify the significant patterns embedded in the collected data. According to the research findings, challenges to PM2.5 pollution mitigation were classified into three regulatory voids: political voids, institutional voids, and knowledge voids. Combining the possible solutions to the regulatory voids and suggestions from all three data sources, alternative solutions to the PM2.5 crisis were conceptualized into a green criminological framework for PM2.5 pollution prevention. The solutions are based on environmental crime prevention approaches, including socio-legal, regulatory, and social action strategies. These approaches emphasize the enhancement of environmental laws and law enforcement, investments in public infrastructure, land use planning, application of economic incentives and technological solutions, and public participation in pollution monitoring.

## Keywords

Air pollution; crime prevention; environmental crime; green criminology; PM2.5

# Introduction

Atmospheric pollution is a significant environmental hazard for human beings. Each year, ambient air pollution contributes to around 6.5 million premature deaths worldwide (Fuller et al., 2022). Nearly 91% of the global population breathes polluted air (Davis, 2020), and 2.6 million Southeast Asian fatalities are found to be associated with all-year-round outdoor air pollution (Saengmanee, 2021). According to Manisalidis et al. (2020), there are six major types of air pollutants. Among them, particulate matter (PM), also known as PM2.5, with sizes less than 2.5 micrometers in diameter, can conveniently enter the respiratory and circulatory systems, causing adverse health impacts such as lung cancer, asthma, chronic obstructive pulmonary disease, stroke, neuroinflammation, oxidative stress, cerebrovascular damage, and vitamin D deficiency (Li & Liu, 2021).

It was estimated that between 2018 and 2021, approximately 87,000 to 150,000 deaths were caused by air pollution in Thailand (Greenpeace, 2018; Greenpeace Southeast Asia, 2022). Bangkok, the capital city of Thailand, has been prone to high-profile PM2.5 pollution episodes over recent years. According to Greenpeace (2018), Bangkok is one of the top five cities in Thailand with the most significant annual PM2.5 concentrations. In January 2019, during a peak period of PM2.5 pollution, hundreds of schools were shut down to control children's exposure to polluted air (IQAir, 2020). Even though PM2.5 pollution can occur naturally, such as through wildfires, it is widely acknowledged that the majority of PM2.5 pollutants are produced by large-scale human activities (Manisalidis et al., 2020). Moreover, previous studies have confirmed that there are three primary sources of PM2.5 pollution in the Bangkok Metropolitan Region, including vehicles and traffic congestion, factories and power plants, and agricultural burning (ChooChuay et al., 2020; EANET, 2020; Kanchanasuta et al., 2020; Kundhikanjana, 2019; Wetchayont et al., 2021).

Academically, an environmental crime like air pollution is becoming a novel crime (White, 2010). An immense and rising number of laws and regulations cover a wide range of behaviors related to environmental violations, and air pollution is emphasized in the fundamental category of these laws (Spapens et al., 2014). As Davies (2014) suggested, air pollution is a serious crime from the green criminological perspective, and air quality regulations must be enforced with an interdisciplinary approach. South (2014a) noted that countless air pollution incidents emerge from transportation, industrial emissions, and agricultural activities; each incident of these is an offense that should be subject to criminal prosecution. However, in Thailand, there are many challenges to air pollution control, such as the political failure to regulate air pollution and conflicts of interest between the state and PM2.5-related industries (Chinwetkitvanich et al., 2021; Marks & Miller, 2022; Panyametheekul & Panswad, 2018).

This article proposes a green criminological framework for PM2.5 pollution prevention grounded on the problem-solving approach. First, we theoretically and empirically review issues related to green criminology, air pollution, regulatory voids in environmental regulations, and green crime prevention. Second, we introduce our research methodology. Third, we analyze the challenges to PM2.5 pollution control in our research settings to apply green crime prevention approaches. Fourth, we propose a holistic framework for PM2.5 pollution prevention based on our analysis in the previous section. Finally, we draw our conclusions and highlight the new knowledge our research produces.

# Literature review

Green criminologists such as de Prez (2000), Fitzgerald and Barat (2010), Katz (2010), and South (2016) have studied existing environmental laws and regulations, including their deficiencies, ineffectiveness, and enforcement failures. Chaiakaraphong and Sirivunnabood (2020) outlined green criminology as an interdisciplinary study exploring environmental crime and its trends and patterns. Beyond the conventional definition of green crime, Lynch and Stretesky (2003) defined a green crime as any action committed by human beings which produces identifiable damage to the environment and living things, especially human health, but may or may not violate existing environmental laws or regulations. This explanation is consistent with the concept of 'primary green crime,' which refers to human activities that directly damage the environment and species (Potter, 2014), for example, crimes of air pollution (e.g., corporate waste burning) (White, 2010). White (2013) similarly asserted that environmental harm should be considered a crime regardless of its legal status. South (2014a) claimed that environmental crime is frequently committed by those with legal standing and legitimate status, especially in politics.

In consistency with Carrabine et al.'s (2009) definition of 'secondary green crime,' an environmental crime emerging from illegitimate or negligent state actions or corporate activities, air pollution is a secondary green crime as it often emerges from the absence, negligence, or avoidance of environmental laws and regulations (White, 2010). White (2009) stated that insufficient environmental pollution regulations and concealment or systematic denial of environmental damage are widely exercised by state agencies operated or funded by business elites. According to South (2014b), air polluters aim to exploit the conditions that follow environmental damage (e.g., convenient removal of crop residue towards open burning) or to violate environmental laws and regulations for gains. Banzhaf et al. (2019) reported that there is a relationship between air pollution and corruption, the misuse of power for personal gains. The regulators often make decisions based on the priorities they give to the interest groups, which means authorities could be a source of excessive exposure to air pollution.

Sahramäki and Kankaanranta (2021) suggested that environmental regulations are hampered by regulatory voids, which can be categorized into 'political,' 'institutional,' and 'knowledge' voids. Political voids refer to obscure legal frameworks and insufficient political assistance for regulatory enforcement and deterrence practices (Sahramäki & Kankaanranta, 2021). Lynch and Stretesky (2003) and Tsikolenko (2017) agreed that only a few international laws have adequately defined green crimes, and violations of environmental laws are barely regarded as illegal in developing countries where the abuse of power undermines criminal justice systems. Lynch (2020) also affirmed that existing environmental laws and regulations manifest the interests of powerful elites. Skinnider (2013) asserted that even though some scholars argue that the definition of green crime should involve 'lawful but awful' activities that cause environmental disruptions, many corporations oppose the idea. From the corporate perspective, if economic advantages outweigh the adverse outcomes of environmentally harmful activities, such activities should be justified as acceptable business practices rather than criminal offenses (Lynch & Stretesky, 2003).

As a result, regulatory bodies have been established to facilitate industries' environmentally damaging activities within legal boundaries. For instance, a small amount of pollution regarded as 'harmless' or 'manageable' is permitted by law, even though the accumulation of

small pollution discharges can severely impact local communities (Skinnider, 2013). De Prez (2000) observed that some regulatory bodies are responsible for promoting business and prosecuting or imposing penalties when a criminal offense arises. Therefore, mission confusion, insufficient resources, and compromise are often impeded by environmental protection agencies or equivalents due to their competing priorities (South, 2014a).

Meanwhile, institutional voids tend to occur when resources and skills are scarce, as well as a lack of planning and management (Sahramäki & Kankaanranta, 2021). According to Tsikolenko (2017), fighting against environmental crime requires not only specialist knowledge and skills but also financial and human resources for conducting inspections. Nonetheless, prosecutors and judges are rarely sufficiently equipped with environmental crime information, and there is a lack of coordination between regulatory entities. South (2014a) reported that, in some countries, environmental regulators are responsible for detecting, deterring, and preventing environmental crime instead of police officers. Instead, these regulators depend on administrative, paper-based monitoring and encourage compliance systems, which are inadequate for coping with high-level or serious offenses. Dependence on polluting industries also reflects the lack of political and economic decentralization. Local communities may need to tolerate significant polluters and their environmentally harmful activities due to the limited job opportunities in the market (Brisman & South, 2015).

Another problem of green crime prevention is knowledge voids or a lack of knowledge and awareness among regulators, victims, and the general public (Sahramäki & Kankaanranta, 2021). Eman et al. (2009) noted that the main features of environmental crime are the collectivity and anonymity of victims, the invisibility of perpetrators, and intangible damage to living things. Skinnider (2013) explained that even if individuals realize the effects of environmental damage, they might not perceive themselves as crime victims or report the damage to enforcement bodies. Identifying environmental crime perpetrators is also an arduous task because the impacts of environmental harm may not be financially quantifiable. The chain of causation is also conventionally long and complex since it ranges from small-scale opportunistic activities to large-scale organized crime involving other serious offenses such as corruption (Brisman & South, 2015; Skinnider, 2013).

The explanations mentioned above are in line with the concept of green victimology, which explains environmental victimization as a commonly slow, undetectable process allowed to legally and systematically take place by the state to benefit specific industries or powerful corporate actors (Angkasa, 2020; Tsiatsianis, 2021; White, 2015). However, being aware of the issues and participating in environmental movements do not guarantee the prevention of green crime and green victimization. Occasionally, lawsuits are used as an offensive weapon against environmentalists, individual citizens, and communities (White, 2003). According to the Human Rights Lawyers Association (2019), private corporations and governments often file strategic lawsuits against public participation (SLAPPs) against individuals who exercise freedom of expression or engage in activities hindering business operations or government projects. As such, SLAPPs typically involve a broad range of tort claims, such as defamation, trespass, and nuisance (Scott & Tollefson, 2010). In Thailand, laws defining SLAPPs do not exist (Business & Human Rights Resource Centre, 2020), considering that the most prominent targets of this kind of lawsuit in this country are political activists, particularly after the latest military coup d'état in 2014, followed by local community leaders and members, human rights defenders, NGO workers, media, lawyers, academics, and victims of environmental harms (Human Rights Lawyers Association, 2019).

Crime prevention refers to any action taken by the public and private sectors to prevent crime and criminal offending and mitigate damage caused by criminal acts (Hughes, 2001; Welsh & Farrington, 2012). Many scholars have studied various environmental crime prevention approaches (Brisman & South, 2015; Goyes et al., 2021; White, 2010). White (2010) most comprehensively proposed integrating socio-legal, regulatory, and social action strategies to solve environmental crime problems. According to White (2003), one of the most common green crime prevention approaches is to enforce environmental laws and regulations.

This socio-legal approach emphasizes the introduction of specific breaches of law, the role of law enforcement agencies, and how to apply criminal law against environmental offenders. Potter (2014) agreed that criminal law had been predominantly utilized to regulate environmentally harmful activities, for instance, the US Clean Air Act of 1956. They also asserted that environmentally harmful activities are increasingly criminalized thanks to the arrival of the Internet. White (2010), however, stated that enforcing environmental law is still an immature area of policing. Sahramäki et al. (2015) supported that improving and regularly updating environmental crime legislation and enforcement is vital to environmental crime prevention.

On the contrary, Brisman and South (2013) pointed out that criminal charges or penalties rarely resolve most environmental violations; administrative, regulatory, or civil mechanisms are more frequently applied. White (2003) agreed that regulatory strategies had been extensively used to improve environmental performance instead of criminal sanctions. The regulatory approach highlights social regulations in the private sector to prevent and reduce environmental damages economically and technologically. To illustrate, the reforms of production and consumption systems can diminish the number of air pollutants produced by the industrial and business sectors (White, 2010).

Another possible solution to environmental crime is applying the social action approach. Democracy and citizen participation in environmental movements can mobilize fundamental social changes, leading to long-term environmental sustainability (White, 2010). South (2014a) suggested that public participation, involvement, and consultation can increase legitimacy and justice in legal and enforcement systems for environmental crime. Pedersen (2014) also stated that the engagement of local communities in the negotiation and application of environmental law enforcement, for example, the request for community compensation, can enhance the acquisition of environmental justice. Nevertheless, firms and the state often impede public participation in environmental protection (White, 2003).

Based on the problem-solving approach for crime prevention (Cherney, 2006), the aforementioned regulatory voids must be reconsidered and emphasized when applying green crime prevention approaches and scrutinizing possible challenges to green crime prevention before devising and implementing strategies to solve the PM2.5 pollution crisis in the Bangkok Metropolitan Region. Nonetheless, our study only offers a framework for crisis mitigation; it does not provide an evaluation of the outcomes of the model's application.

# Materials and methods

In this study, primary and secondary data were collected from multiple data sources and by data collection methods: documentary research, in-depth interviews, and focus group

discussions. This data triangulation technique was employed to increase the validity and reliability of the research findings.

First, documentary research was conducted to obtain relevant information from secondary sources such as laws and bills, policies, news articles, journal articles, textbooks, and case studies in Thailand and other foreign countries. The collected data was subsequently applied to the research database development and questions for in-depth interviews and focus groups. Next, 14 in-depth interviews and 2 focus groups were conducted to collect primary data. Selected by two non-probability sampling techniques, purposive sampling and snowball sampling, there were 14 interviewees and 6 participants for each focus group (26 participants in total). Parker et al. (2019) explained that snowball sampling is often combined with purposive sampling to reach data saturation. Since it is challenging to achieve the required quota of participants by direct selection (purposive sampling), some of them were recruited through referrals from the initial participants (snowball sampling). The participants' professional roles and responsibilities were associated with air pollution control or green crime prevention in Thailand.

This study was approved by the Committee for Research Ethics (Social Sciences) of Mahidol University, Thailand (COA No. 2021/103.0909). Likewise, all participants provided written informed consent prior to enrolment in the study. In this research project, the participants are comprised of:

- ASEAN Working Group on Climate Change (AWGCC) officers
- ASEAN Working Group on Environmentally Sustainable Cities (AWGESC) officers
- Experts and scholars in the field of politics, economics, environmental science, and public administration
- Local community leaders
- Local entrepreneurs in PM2.5-related industries
- Local governmental officers
- Non-governmental organization (NGO) officers

Finally, qualitative content analysis was applied to identify the significant patterns embedded in the reviewed documents, interview transcripts, and focus group transcripts.

# Findings and discussion

In this section, we contextually analyze and discuss our findings by categorizing them into sub-themes: 1) challenges to PM2.5 pollution mitigation in the Bangkok Metropolitan Region and 2) green criminological solutions to the PM2.5 crisis. With regard to the problem-solving approach, we identified the challenges to explore optimal solutions for the crisis. The proposed alternative solutions were conceptualized into a framework based on the green criminological perspective.

## Challenges to PM2.5 pollution mitigation in Bangkok Metropolitan Region

Based on the regulatory voids proposed by Sahramäki and Kankaanranta (2021), we classified our research findings on the challenges to PM2.5 pollution mitigation in the Bangkok Metropolitan Region into three areas: political, institutional, and knowledge voids.

In terms of political voids, most participants agree that neither legal frameworks nor political support for regulatory enforcement concerning PM2.5 pollution are sufficient in Thailand. A law explicitly focusing on air pollution or strategic lawsuits against public participation does not exist in the country (Business & Human Rights Resource Centre, 2020; Thailand Clean Air Network, 2019). Moreover, the Thai parliament has constantly dismissed the Clean Air Bills for doubtful financial reasons, showing legislative and political obstacles hindering policy movement against air pollution (Chan, 2022; Teeratanabodee, 2021). Most participants suggested that Thailand's PM2.5 regulations are too relaxed. Regarding the industrial sector in particular, foreign investors tend to select Thailand as their production base because environmental laws are weaker here. Consistent with a report conducted by Wipatayotin and Ngamkham (2018), one informant elaborated:

> *"For example, the waste treatment and recycling industries in Thailand are fundamentally invested by Chinese entrepreneurs. As the Chinese government prohibits the import of recyclable waste, these industries move to Thailand where the government encourages foreign investments towards the amendments of the Factory Act and land use planning regulations."*

Most focus group participants and three interviewees also claimed that the air quality standards are outdated. The PM2.5 air quality standard was introduced in Thailand in 2010. However, the yearly PM2.5 concentrations have continuously exceeded the national air quality standard levels of 25 μg/m3 since 2012. In 2017, Bangkok's annual average PM2.5 concentrations were 42 μg/m3 (Narita et al., 2019). An informant stated that Thailand's PM2.5 emission ceilings are 2 to 3 times higher than the World Health Organization's standards. This finding conforms to a report by Buakamsri (2019) in which Thailand had set its permissible PM2.5 level at 25 μg/m3 and 50 μg/m3 per year and per day, respectively. Still, these targets were double the World Health Organization's standards (10 μg/m3 and 25 μg/m3 yearly and daily, respectively). One of the participants explained:

> *"Environmental laws and their enforcement in Thailand are increasingly complex day by day. When I conducted research on PM2.5 almost 17 years ago, nobody knew about dust pollution. Only over the past 2–3 years, have Thai people started to be concerned about PM2.5. This reflects that the environmental laws must be amended over time."*

One participant stated that the existing laws do not identify vehicle age limits. The age of public buses and private cars is not restricted. Another informant said specific standards for PM2.5 industrial emissions do not exist. Four participants agreed there is also a lack of control in the industrial and construction sectors. Even though each does not excessively release air pollutants, when combining them all, the total amount of pollutants exceeds the city's carrying capacity, especially in winter. This finding is consistent with previous studies (Htwe et al., 2021; Pollution Control Department, 2018), which suggested that the PM2.5 concentrations in

the Bangkok Metropolitan Region had exceeded the safety threshold and the land carrying capacity. One participant raised an important question:

> *"The policymakers often forget about the scenario where there is not only this factory but also other 1,000 similar factories in the area. Should we continue using the same emission standard if there are more factories in the future while the land carrying capacity remains the same?"*

Two participants pointed out that laws and regulations related to PM2.5 are divergent in Thailand, leading to overlapping jurisdictions. One of them clarified that different regulations from different agencies had been implemented due to various sources of PM2.5 particles. Three participants stated that too many ministries and agencies are responsible for diverse sources of PM2.5, including the Ministry of Health Care, Ministry of Natural Resources and Environment, Ministry of Industry, Ministry of Transport, and local administrations such as the Bangkok Metropolitan Administration. Consequently, the definitions and punishments for PM2.5 polluting activities are diversified, and there is a lack of integration and coordination between regulatory agencies. The police, the centrally responsible law enforcement agency, are often tasked with many duties, leading to their ignorance of air pollution complaints. One informant reported:

> *"When the district officers collected and submitted the relevant evidence to the file complaints at the police stations, the complaints were rarely followed up. The local administrations followed up on the cases because there were victims affected by the pollution, but the cases were slowly processed by the police. The law should be revised to increase authority to administrative officers, including the authority to prosecute and impose penalties by ourselves."*

In agreement with prior research (Davis & Abraham, 2013; de Prez, 2000; Ellefsen et al., 2012; South, 2014a), PM2.5-related regulatory agencies in Thailand are also exposed to conflicts of interest and corruption. One participant argued that the primary responsibility of the Ministry of Industry is to support and promote industries. However, the Ministry of Industry is also obliged to maintain environmental safety and prevent pollution caused by the industrial sector (Marks & Miller, 2022). Such internal conflict leads to the relaxation of regulations and widespread corruption practices. Two informants revealed that most PM2.5-polluting industries are closely tied to the government, so their decisions influence public policies. For instance, the Strategy Committee for Commercial Viability of Four Agricultural Products (i.e., corn fodder, tapioca, palm oil, and sugar cane) was established by the National Council for Peace and Order (NCPO) in 2014 (Ministry of Foreign Affairs, 2014). In 2015, the Ministry of Industry under the NCPO announced a public policy on expanding sugar production factories across the nation, drastically affecting the national environment (Voice Online, 2020). One informant disclosed:

> *"The PM2.5 pollution in Bangkok metropolis and its vicinities is partially caused by the wide expansion of monocultural plantations such as sugarcane, corn, and off-season rice. Sixty percent of sugarcane fields involved illegal open burning, while 50% of off-season paddy fields also involved such practice."*

Nonetheless, another informant argued that many big corporations involved in open burning have threatened to sue whoever accused them as a source of pollutants. The corporations

claim they burn the fields by themselves; however, they still buy products from open burning. One informant explained that this action should be considered a strategic lawsuit against public participation (SLAPP). Another participant said not all entrepreneurs are ready for air quality standard improvements, causing delays in the development process. The fact that the government has been waiting for them to be prepared, despite the vast impacts on public health and climate change, should be considered a conflict of interest. One participant added that short-term measures are more applied due to political instability. The policymakers focus on their voting base rather than public interests.

Regarding institutional voids, four participants mentioned insufficient staffing for investigation and prosecution as the main problem of PM2.5 mitigation. Personnel shortages and time limits while being on duty impair the performance of law enforcement officers. One informant disclosed that approximately three million vehicles are moving in and out of the Bangkok metropolis and its vicinities each year. However, the officers can inspect less than one million of these vehicles annually. Apart from the inadequate regulatory workforce, several participants recognized the lack of regulatory knowledge and skills as a strategic concern.

One informant supported that the local administrations are unfamiliar with the amended Factory Act, which has transferred the supervision authority from the Ministry of Industry to local administrations for less than two years. This finding corresponds with a study by Karnjanawat and Mallikamarl (2011) in which local administrative organizations rarely clearly understand the scope of their duties and powers for mitigating environmental pollution as addressed in various laws. Another informant explained:

> *"The Department of Industrial Works has transferred our authority to control Type 1 and Type 2 factories to the local administrations. Unfortunately, some local administrations do not have adequate knowledge or knowledgeable officers to monitor the factories. Hence, the environmental damages are barely controlled."*

Most participants emphasized high investment costs as the biggest problem of PM2.5 pollution prevention. One of the participants explained that it is difficult to scientifically differentiate the sources of PM2.5 due to the high research costs, making it challenging to solve the pollution problems from their root causes.

> *"Even though the existing technologies like the organic carbon or elemental carbon component analysis can help us identify the sources, they cannot be regularly applied owing to the high capital costs, complex research processes, expensive equipment, and high demand for research teams and investors."*

High investment costs also impact the willingness to reduce PM2.5 emissions among entrepreneurs. One informant said firms always avoid more expenses at all costs, which affects the development of technological incentives for the industrial and agricultural sectors. Another informant supported this:

> *"The farmers want to get rid of the waste from their business activities immediately. It is more convenient to burn. It is the cheapest way. Relocating factories to special economic zones is also inconvenient for small and medium-sized firms."*

The lack of public transport and poor urban planning caused by economic centralization and rapid urbanization were also mentioned. Two participants argued that inadequate and disorganized transportation infrastructure (e.g., overpriced BTS Skytrain fares, decayed footpaths, and poorly-maintained buses) forces people living in the Bangkok Metropolitan Region to use private cars regularly. Another informant pointed out that the Bangkok metropolis and its vicinities are facing problems of 'vertical cities' due to the lack of wind and ventilation. The high-rise buildings acted as heat domes that constantly trapped dust pollutants within the city. This finding adheres to a study by Brisman and South (2015), which discovered that the lack of political and economic decentralization could lead to ineffective urban planning and environmental deterioration.

Lastly, knowledge voids affecting the PM2.5 crisis in the Bangkok Metropolitan Region include the lack of public and corporate awareness and the scarcity of information about PM2.5 sources. Two participants stated that very few Thai citizens are aware of the severe consequences of PM2.5. There is a lack of knowledge about the connection between environmental hazards and corruption. A participant stated that fewer people are aware of their power to pressure the government or even the private sector to make ecological changes for public interests. Especially in the case of farmers involved in open burning, three participants pointed out that the absence of awareness results from poverty and the lack of education. Another informant affirmed that few entrepreneurs research PM2.5 pollution or know about the citizen-driven Clean Air Bill.

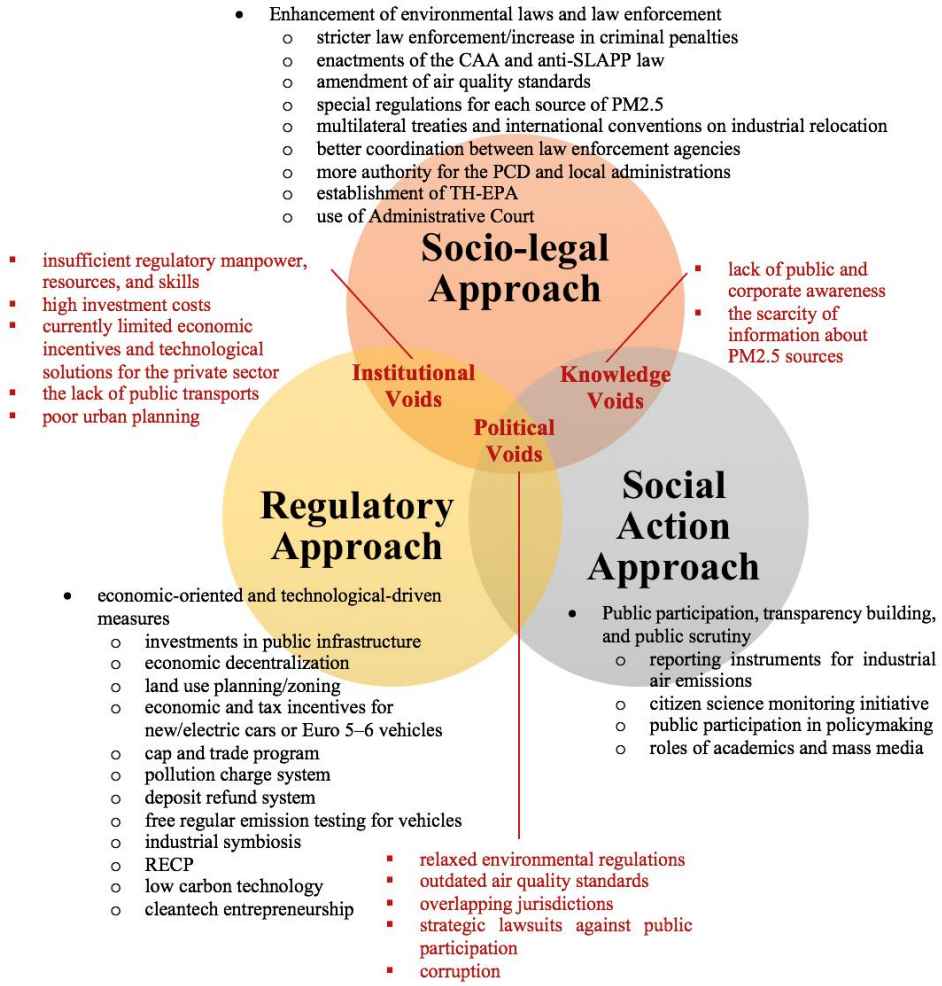
> *"Hired external investigators like us need to treat the factories as our customers. We need to find any possible means to help them get the licenses. Japanese factories are more knowledgeable and disciplined. They change or repair their equipment even before the expiring dates."*

This finding is consistent with previous scholarly works (Eman et al., 2009; Nikam et al., 2021), by which the lack of public awareness of the health impacts of PM2.5 is standard, while the general public is rarely aware of environmental crime or environmental victimization.

As illustrated in the next section, the aforementioned political, institutional, and knowledge voids are incorporated into our green criminological framework for PM2.5 pollution prevention.

## Green Criminological Solutions to the PM2.5 Crisis

**Figure 1:** Green Criminological Framework for PM2.5 Pollution Prevention




*Note: Developed by Authors*

Based on the green criminological perspective, we designed a framework for the Bangkok Metropolitan Region's PM2.5 crisis mitigation by applying White's (2010) environmental crime prevention approaches in socio-legal, regulatory, and social action (see Figure 1). Our originally developed green criminological framework also aims to solve the regulatory voids discussed in the previous section, to prevent PM2.5 pollution more effectively. The following solutions are proposed to integrate primary and secondary data from different data collection methods.

According to Figure 1, our socio-legal approach focuses on enhancing environmental laws and law enforcement. The following solutions are expected to resolve political and institutional voids, such as relaxed environmental regulations, outdated air quality standards, overlapping jurisdictions, strategic lawsuits against public participation, and insufficient regulatory staffing, resources, and skills.

- First, there should be stricter law enforcement or an increase in criminal penalties to prevent and suppress both dust pollutant production and corruption, for example, an increase in fines for polluting activities or an increase in penalties on conspiracy under the Anti-Money Laundering Act.

- Second, new laws such as the Clean Air Act (CAA) and the Anti-SLAPP Law are required. The proposed CAA emphasizes integrative law enforcement, decentralization of law enforcement authority (separated into policy level, regulatory level, and operational level), the right to public participation in clean air management, the right to access environmental justice, and the right to information about air quality (Boonlert, 2021; Thailand Clean Air Network, 2019).

- Third, the air quality standards and emission standards must be revised. According to Nikam et al. (2021), the daily average PM2.5 interim standard should be changed from 50 to 37.5 µg/m3. Emission standards for automobile and crude oil refining industries should be advanced to Euro 5–6 (or higher). Multilateral treaties and international conventions between Thailand and other countries (e.g., the United States and China) are compulsory for preventing or limiting the relocation of polluting activities from overseas.

- Fourth, there should be more integration between law enforcement agencies and regulatory bodies such as the Pollution Control Department, and local administrations should be equipped with more authority and resources. The proposed Clean Air Bill requires better coordination between regulatory bodies and establishing of the Thai Environmental Protection Agency (TH-EPA) acting as an ad hoc agency for PM2.5 pollution management (Thailand Clean Air Network, 2019).

- Fifth, special regulations for each source of PM2.5 and policy corruption should be adopted, for instance, prohibition of night operations, industrial zoning regulations, monocultural land expansion regulations, and a quota system limiting time and place of construction or transportation activities. Additional legal measures, such as a whistleblower protection policy or information disclosure policy, can be implemented to tackle corruption related to PM2.5 pollution (Juangjun, 2015).

- Sixth, the use of the Administrative Court is considered essential for environmental cases. The court usually requests researchers to provide information or conduct additional research to make a judgment, remedy, and prevent adverse environmental impacts more productively (Administrative Court of Thailand, 2013).

Alternatively, our regulatory approach applies social control measures as preventive mechanisms since the crime control model does not always work. More economic-oriented and technological-driven measures should be implemented to motivate the private sector to set emission goals and reduce pollutant emissions. These solutions are expected to minimize institutional voids, such as high investment costs, currently limited economic and technological incentives for the private sectors, the lack of public transport, and poor urban planning. They are also predicted to reduce corrupt practices, a political void committed by firms.

- First, there must be investments in public infrastructure, such as a regular expansion and fare control of the Bangkok Mass Transit System (or the "BTS Skytrain"), to reduce vehicular emissions and traffic congestion. Eco-friendly tram services, more footpaths, bus stops, well-connected multi-model pathways for bicycling and walking, and green spaces under viaducts or flyovers should be provided.

- Second, the extension of public transport and business areas from Bangkok metropolis to the vicinities and then to other provinces is an economic decentralization approach

for solving problems of vertical cities. Land use planning, for example, co-location or proximity reduction between where people live and where they work, should be promoted to increase transportation efficiency.

- Third, economic and tax incentives should be developed. Stair-step incentives for all stakeholders, for instance, more tax waived for the SMEs, are recommended. More economic incentives for newer or electric cars or Euro 5–6 vehicles include tax credits, exemptions from emissions testing, utility time-of-use rate reductions, free or subsidized renewal of heating and energy-saving systems, and lower taxes for electric or hybrid car purchases (Nikam et al., 2021; Sofia et al., 2020). The 'cap and trade' program should be introduced to reduce emissions, mainly from power plants (Stavins, 2008). A pollution charge system can measure a fee or tax based on the pollution produced by firms (Stavins & Whitehead, 1992). Stavins (1997) stated that a deposit refund system allows consumers to pay a surcharge when purchasing potentially polluting products or related goods, such as crops for feeding animals gained from the agricultural burning method.

- Fourth, various technological resolutions can be applied. There must be regular emission testing for vehicles provided by the public sector for traffic pollution. Examples of technical solutions for the industrial and agricultural sectors include industrial symbiosis (Alfaro & Miller, 2014; Chertow, 2007), resource-efficient and cleaner production (RECP) (Vargas et al., 2019), low carbon technology (Lv & Qin, 2016), and United Nations Industrial Development Organization's cleantech entrepreneurship (UNIDO, 2017).

- Fifth, subsidizing air purification towers or free access is suggested for PM2.5-concentrated zones such as high-traffic areas, industrial estates, and open burning hotspots. Januszkiewicz and Kowalski (2019) reported that in 2018, the world's largest air purifier using the Solar-assisted Large-scale Cleaning System (SALSCS) was tested in Xi'an, a metropolitan city in China. The 100-meter-tall air purification tower has enhanced the city's air quality by generating more than 10 million cubic meters of clean air daily. In 2019, the BMA also announced a pilot project to install a four-meter air purification tower in central Bangkok. The tower was expected to clean polluted air up to a radius of 1,000 meters. If the tower proved capable of decreasing PM2.5 pollution, the BMA would request firms, department stores, and high-rise buildings to install similar towers (Bangkok Post, 2019).

Finally, our social action approach highlights public participation (i.e., political groups, social movement groups, citizens, and scholars) in PM2.5 pollution prevention. This process also includes transparency building and public scrutiny of laws and policies regarding dust problems. Social action resolves not only knowledge voids but also political voids regarding corruption.

- First, public participation and disclosure of information are critical solutions. The public should have been allowed to know the amount of dust released by the factories and other sources. Otherwise, they would not know whom they needed to complain or accuse when they were already victimized. There must be public access to information about industrial air emissions through reporting instruments such as stack emission monitoring, emission inventory (EI), pollutant release and transfer registers (PRTR), and toxics release inventory. This realization conforms to the recommendations given by Thailand Clean Air Network (2020). Alternatively, a

citizen science monitoring initiative should be promoted to obtain data from informal monitoring stations and home-based or office-based monitoring equipment. Such as with a successful case of citizens monitoring indoor and outdoor air pollutants in Madrid, which could protect the local children's health (Health and Environment Alliance, 2019). According to Nikam et al. (2021), local communities must be equipped with greater power in the decision-making process of any air-polluting development projects at the policy level.

- Second, public awareness of the impacts of PM2.5 and corruption can be raised by the academic sector and mass media. It is important to "speak truth to power" (Buchanan & Badham, 2020) to reduce the influence of government propaganda or fake news related to PM2.5 pollution, scrutinize whether the public sector follows the academic recommendations of every government project, and rapidly spread information and provide evidence of criminal attempts towards social media. Theoretically, this conforms to the concept of corruption and policy corruption (Klitgaard, 1998; Mahakul, 2017; Sriphonkrang, 2017) by which PM2.5 pollution mismanagement can be mitigated by accountability obtained towards public participation and mass media scrutiny.

# Conclusion

The key contribution of our research was the development of a green criminological framework for mitigating PM2.5 pollution in the Bangkok Metropolitan Region. Based on the problem-solving approach, we identified the regulatory voids of PM2.5 pollution prevention in the research settings to determine optimal solutions for the crisis. In reference to Sahramäki and Kankaanranta (2021), these regulatory voids were classified into political, institutional, and knowledge voids. Subsequently, we conceptualized the alternative solutions to the PM2.5 crisis into a framework primarily based on White's (2010) green crime prevention approaches.

The socio-legal approach emphasizes the enhancement of environmental laws and law enforcement. The regulatory approach concentrates on the application of economic and technological solutions. The social action approach focuses on public participation in knowledge sharing, pollution monitoring, and scrutiny. These approaches are expected to resolve the regulatory voids identified in this study. Ultimately, our developed framework can be further applied by the public, private, civil, and academic sectors to prevent PM2.5 pollution in the research areas effectively and sustainably. It can be concluded that this study contributes to the improvement of human health as well as the relationship between human activities and the environment.

Future investigations are necessary for validating the usefulness of the developed framework. Our study provides a positive starting point for the potential use of green crime prevention approaches to solving other environmental crimes, especially water and hazardous waste pollution.

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